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(71)Applicant : MATSUSHITA ELECTRIC IND CO LTD
(72)Inventor : MIZUNO KO
TERAI KENICHI
HASHIMOTO HIROYUKI
KAKUBARI ISAO
ABE KAZUTADA

(54) SOUND IMAGE LOCALIZATION CONTROL DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To reduce a signal processing computation amount and to obtain a good sound image localization control effect in a sound image localization control device for reproducing, by a speaker or headphones set in another place, a sound characteristic replayed by a speaker set in a predetermined place.
SOLUTION: In a high-frequency band in which a head acoustic transfer function indicates a complicated characteristic, a characteristic of replay means is corrected to a characteristic of the head acoustic transfer function by finite- impulse response (FIR) type filter processing. In a low-frequency band in which the characteristic of the head acoustic transfer function can be represented by a level difference between both ears and a time difference between both ears, the characteristic of the replay means is corrected to the characteristic of the head acoustic transfer function by infinite-impulse response (IIR) type filter processing, gain setting, and delay processing.

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CLAIMS

[Claim(s)]

[Claim 1] The 1st infinite impulse response filter which inputs an acoustic signal and performs the image static control of a low frequency band, The 1st finite impulse response mold filter which inputs the output signal of said 1st infinite impulse response filter, and performs the image static control of a high-frequency band, The 2nd infinite impulse response filter which inputs an acoustic signal and performs the image static control of a low frequency band, The 2nd finite impulse response mold filter which inputs the output signal of said 2nd infinite impulse response filter, and performs the image static control of a high-frequency band, Image static-control equipment characterized by having a sound reproduction means to reproduce the output signal of said 1st finite impulse response mold filter, and the output signal of said 2nd finite impulse response mold filter.

[Claim 2] The 1st infinite impulse response filter which inputs an acoustic signal, and the 1st gain setter which inputs the output signal of said 1st infinite impulse response filter, The 1st finite impulse response mold filter which inputs the output signal of the 1st delay machine which inputs the output signal of said 1st gain setter, and said 1st delay machine, The 2nd infinite impulse response filter which inputs an acoustic signal, and the 2nd gain setter which inputs the output signal of said 2nd infinite impulse response filter, The 2nd finite impulse response mold filter which inputs the output signal of the 2nd delay machine which inputs the output signal of said 2nd gain setter, and said 2nd delay machine, It is image static-control equipment equipped with a sound reproduction means to reproduce the output signal of said 1st finite impulse

response mold filter, and the output signal of said 2nd finite impulse response mold filter. Said 1st infinite impulse response filter, the 1st gain setter, the 1st delay machine, said 2nd infinite impulse response filter, the 2nd gain setter, and the 2nd delay machine perform the image static control of the low frequency band of an acoustic signal. Said 1st finite impulse response mold filter and said 2nd finite impulse response mold filter are image static-control equipment characterized by performing the image static control of the high-frequency band of an acoustic signal.

[Claim 3] The infinite impulse response filter which inputs an acoustic signal, and the 1st delay machine which inputs the output signal of said infinite impulse response filter, The 1st finite impulse response mold filter which inputs the output signal of the 1st gain setter which inputs the output signal of said 1st delay machine, and said 1st gain setter, The 2nd gain setter which inputs the output signal of said 1st delay machine, and the 2nd delay machine which inputs the output signal of said 2nd gain setter, The 2nd finite impulse response mold filter which inputs the output signal of said 2nd delay machine, It is image static-control equipment equipped with a sound reproduction means to reproduce the output signal of said 1st finite impulse response mold filter, and the output signal of said 2nd finite impulse response mold filter. Said infinite impulse response filter, the 1st gain setter, the 1st delay machine, said 2nd gain setter, and the 2nd delay machine perform the image static control of the low frequency band of an acoustic signal. Said 1st finite impulse response mold filter and said 2nd finite impulse response mold filter are image static-control equipment characterized by performing the image static control of the high-frequency band of an acoustic signal.

[Claim 4] The low pass filter which extracts a low frequency band signal from an acoustic signal, and the 1st infinite impulse response filter which inputs the output signal of said low pass filter, The 1st gain setter which inputs the output signal of said 1st infinite impulse response filter, The 1st delay machine which inputs the output signal of said 1st gain setter, and the 2nd infinite impulse response filter which inputs the output signal of said low pass filter, The 2nd gain setter which inputs the output signal of said 2nd infinite impulse response filter, The 2nd delay machine which inputs the output signal of said 2nd gain setter, and the high-pass filter which extracts a high-frequency band signal from an acoustic signal, The 1st finite impulse response mold filter which inputs the output signal of said high-pass filter, The 2nd finite impulse response mold filter which inputs the output signal of said high-pass filter, The 1st adder adding the output signal of said 1st delay machine, and the output signal of said 1st finite impulse response mold filter, The 2nd adder adding the output signal of said 2nd delay machine, and the output signal of said 2nd finite impulse response mold filter, It is image static-control equipment equipped with a sound reproduction means to reproduce the output signal of said 1st adder, and the output signal of said 2nd adder. Said 1st infinite impulse response filter, the 1st gain setter, the 1st delay machine, said 2nd infinite impulse response filter, the 2nd gain setter,

and the 2nd delay machine perform the image static control of the low frequency band of an acoustic signal. Said 1st finite impulse response mold filter and said 2nd finite impulse response mold filter are image static-control equipment characterized by performing the image static control of the high-frequency band of an acoustic signal.

[Claim 5] The low pass filter which extracts a low frequency band signal from an acoustic signal, and the infinite impulse response filter which inputs the output signal of said low pass filter, The 1st delay machine which inputs the output signal of said infinite impulse response filter, The 1st gain setter which inputs the output signal of said 1st delay machine, and the 2nd delay machine which inputs the output signal of said 1st delay machine, The 2nd gain setter which inputs the output signal of said 2nd delay machine, and the high-pass filter which extracts a high-frequency band signal from an acoustic signal, The 1st finite impulse response mold filter which inputs the output signal of said high-pass filter, The 2nd finite impulse response mold filter which inputs the output signal of said high-pass filter, The 1st adder adding the output signal of the output signal of said 1st gain setter, and the output signal of said 1st finite impulse response mold filter, The 2nd adder adding the output signal of the output signal of said 2nd gain setter, and the output signal of said 2nd finite impulse response mold filter, It is image static-control equipment equipped with a sound reproduction means to reproduce the output signal of said 1st adder, and the output signal of said 2nd adder. Said infinite impulse response filter, the 1st gain setter, the 1st delay machine, the 2nd gain setter, and the 2nd delay machine perform the image static control of the low frequency band of an acoustic signal. Said 1st finite impulse response mold filter and said 2nd finite impulse response mold filter are image static-control equipment characterized by performing the image static control of the high-frequency band of an acoustic signal.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the image static-control equipment which realizes the normal position of an acoustic signal head outside.

[0002]

[Description of the Prior Art] Conventionally, in audio playback, various technique for making the image orientate in the direction of a sound source is proposed.

[0003] Using a dummy head etc., from the head sound transfer function from real sources, such as a loudspeaker, to a dummy head, and the transfer function of the

headphone with which the dummy head was equipped, the image static control using headphone asks for the filter shape for image static controls, and carries out signal processing of the acoustic signal for this as a multiplier of a digital filter. If an image static control is performed using a finite impulse response mold filter (it considers as an FIR filter hereafter), since the number of taps of an FIR filter will become large and the amount of signal-processing operations will become huge, the image static-control equipment which can stop the amount of signal-processing operations is proposed by using together and carrying out the image static control of the infinite impulse response filter (it considering as an IIR filter hereafter) and FIR filter which can adjust frequency characteristics with the small number of taps.

[0004] Hereafter, the conventional image static-control equipment using headphone is explained, referring to a drawing. Drawing 21 is drawing showing the basic configuration of the solid acoustical-treatment equipment shown in JP,9-84199,A. In drawing 21 , the amplifier as for which, as for the delay section, 2a, and 2b, 1a and 1b control gain, the IIR filter with which 3a and 3b add a target property, i.e., the frequency characteristics of the head sound transfer function about a target sound source, the FIR filter from which 4a and 4b remove the acoustic feature of headphone, and 5 are filter factor selection means perform a selection setup of the filter factor, the delay, and the gain which are used for control based on the listening person positional information inputted.

[0005] Actuation of the equipment shown in drawing 21 is explained below. The multiplier expressing both the lugs time difference of the impulse response of a target property is beforehand set to the delay sections 1a and 1b by the filter factor selection means 5. To amplifier 2a and 2b The multiplier expressing both the lugs level difference of the impulse response of a target property is beforehand set up by the filter factor selection means 5. In the IIR filters 3a and 3b The multiplier expressing the frequency characteristics of a target property is beforehand set up by the filter factor selection means 5, and the multiplier expressing the reverse property of the impulse response of the headphone which are output means and which are not illustrated is beforehand set to the FIR filters 4a and 4b by the filter factor selection means 5.

[0006] Signal processing of the input signal is carried out to the delay sections 1a and 1b and the IIR filters 3a and 3b by amplifier 2a and 2b, and the time amount property and frequency characteristics of the head sound transfer function H which are target properties are amended. Reverse property 1 / C of the acoustic feature C of headphone are amended by carrying out signal processing of the output of amplifier 2a and 2b with the FIR filters 4a and 4b. Therefore, if it listens to the output of the FIR filters 4a and 4b through headphone, a listening person can sense that ** is also hearing the sound from a target sound source.

[0007] Although the amount of signal-processing operations can be stopped to about 10 tap extent compared with the case where the IIR filters 3a and 3b amend the

property of a head sound transfer function by FIR filtering, control precision falls in the high-frequency band where a head sound transfer function shows a complicated property, and it becomes difficult to provide a listening person with the good image normal position. Moreover, it is difficult to reduce the number of filter taps, maintaining a low-pass amendment precision, since amendment of a sound reproduction means reverse property is crossed to a perimeter wave number band and uses the FIR filters 4a and 4b.

[0008]

[Problem(s) to be Solved by the Invention] This invention aims at reducing the amount of signal-processing operations for an image static control, and providing a listening person with the accurate image normal position over a perimeter wave number band in view of said technical problem.

[0009]

[Means for Solving the Problem] The 1st infinite impulse response filter which the image static-control equipment of this invention inputs an acoustic signal, and performs the image static control of a low frequency band, The 1st finite impulse response mold filter which inputs the output signal of said 1st infinite impulse response filter, and performs the image static control of a high-frequency band, The 2nd infinite impulse response filter which inputs an acoustic signal and performs the image static control of a low frequency band, The 2nd finite impulse response mold filter which inputs the output signal of said 2nd infinite impulse response filter, and performs the image static control of a high-frequency band, It is characterized by having a sound reproduction means to reproduce the output signal of said 1st finite impulse response mold filter, and the output signal of said 2nd finite impulse response mold filter.

[0010] Moreover, the 1st infinite impulse response filter into which the image static-control equipment of this invention inputs an acoustic signal, The 1st gain setter which inputs the output signal of said 1st infinite impulse response filter, The 1st finite impulse response mold filter which inputs the output signal of the 1st delay machine which inputs the output signal of said 1st gain setter, and said 1st delay machine, The 2nd infinite impulse response filter which inputs an acoustic signal, and the 2nd gain setter which inputs the output signal of said 2nd infinite impulse response filter, The 2nd finite impulse response mold filter which inputs the output signal of the 2nd delay machine which inputs the output signal of said 2nd gain setter, and said 2nd delay machine, It is image static-control equipment equipped with a sound reproduction means to reproduce the output signal of said 1st finite impulse response mold filter, and the output signal of said 2nd finite impulse response mold filter. Said 1st infinite impulse response filter, the 1st gain setter, the 1st delay machine, said 2nd infinite impulse response filter, the 2nd gain setter, and the 2nd delay machine perform the image static control of the low frequency band of an acoustic signal. Said 1st finite impulse response mold filter and said 2nd finite impulse

response mold filter are characterized by performing the image static control of the high-frequency band of an acoustic signal.

[0011] Moreover, the infinite impulse response filter into which the image static-control equipment of this invention inputs an acoustic signal, The 1st delay machine which inputs the output signal of said infinite impulse response filter, The 1st finite impulse response mold filter which inputs the output signal of the 1st gain setter which inputs the output signal of said 1st delay machine, and said 1st gain setter, The 2nd gain setter which inputs the output signal of said 1st delay machine, and the 2nd delay machine which inputs the output signal of said 2nd gain setter, The 2nd finite impulse response mold filter which inputs the output signal of said 2nd delay machine, It is image static-control equipment equipped with a sound reproduction means to reproduce the output signal of said 1st finite impulse response mold filter, and the output signal of said 2nd finite impulse response mold filter. Said infinite impulse response filter, the 1st gain setter, the 1st delay machine, said 2nd gain setter, and the 2nd delay machine perform the image static control of the low frequency band of an acoustic signal. Said 1st finite impulse response mold filter and said 2nd finite impulse response mold filter are characterized by performing the image static control of the high-frequency band of an acoustic signal.

[0012] Moreover, the low pass filter with which the image static-control equipment of this invention extracts a low frequency band signal from an acoustic signal, The 1st infinite impulse response filter which inputs the output signal of said low pass filter, The 1st gain setter which inputs the output signal of said 1st infinite impulse response filter, The 1st delay machine which inputs the output signal of said 1st gain setter, and the 2nd infinite impulse response filter which inputs the output signal of said low pass filter, The 2nd gain setter which inputs the output signal of said 2nd infinite impulse response filter, The 2nd delay machine which inputs the output signal of said 2nd gain setter, and the high-pass filter which extracts a high-frequency band signal from an acoustic signal, The 1st finite impulse response mold filter which inputs the output signal of said high-pass filter, The 2nd finite impulse response mold filter which inputs the output signal of said high-pass filter, The 1st adder adding the output signal of said 1st delay machine, and the output signal of said 1st finite impulse response mold filter, The 2nd adder adding the output signal of said 2nd delay machine, and the output signal of said 2nd finite impulse response mold filter, It is image static-control equipment equipped with a sound reproduction means to reproduce the output signal of said 1st adder, and the output signal of said 2nd adder. Said 1st infinite impulse response filter, the 1st gain setter, the 1st delay machine, said 2nd infinite impulse response filter, the 2nd gain setter, and the 2nd delay machine perform the image static control of the low frequency band of an acoustic signal. Said 1st finite impulse response mold filter and said 2nd finite impulse response mold filter are characterized by performing the image static control of the high-frequency band of an acoustic signal.

[0013] Moreover, the low pass filter with which the image static-control equipment of this invention extracts a low frequency band signal from an acoustic signal, The infinite impulse response filter which inputs the output signal of said low pass filter, The 1st delay machine which inputs the output signal of said infinite impulse response filter, The 1st gain setter which inputs the output signal of said 1st delay machine, and the 2nd delay machine which inputs the output signal of said 1st delay machine, The 2nd gain setter which inputs the output signal of said 2nd delay machine, and the high-pass filter which extracts a high-frequency band signal from an acoustic signal, The 1st finite impulse response mold filter which inputs the output signal of said high-pass filter, The 2nd finite impulse response mold filter which inputs the output signal of said high-pass filter, The 1st adder adding the output signal of the output signal of said 1st gain setter, and the output signal of said 1st finite impulse response mold filter, The 2nd adder adding the output signal of the output signal of said 2nd gain setter, and the output signal of said 2nd finite impulse response mold filter, It is image static-control equipment equipped with a sound reproduction means to reproduce the output signal of said 1st adder, and the output signal of said 2nd adder. Said infinite impulse response filter, the 1st gain setter, the 1st delay machine, the 2nd gain setter, and the 2nd delay machine perform the image static control of the low frequency band of an acoustic signal. Said 1st finite impulse response mold filter and said 2nd finite impulse response mold filter are characterized by performing the image static control of the high-frequency band of an acoustic signal.

[0014]

[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained using drawing 20 from drawing 1 .

[0015] (Gestalt 1 of operation) Drawing 1 is image static-control equipment of the L front sound source of the gestalt 1 of operation. 5a and 5b are an IIR filter and the listening person whom an FIR filter, and 7a and 7b equipped with the headphone playback unit, and, as for 6a and 6b, 8 equipped with headphone. After signal processing of the inputted L front acoustic signal is carried out with the IIR filters 5a and 5b and the FIR filters 6a and 6b, it is inputted into the headphone playback units 7a and 7b. The listening person 8 listens to the output signal of the playback units 7a and 7b. The multiplier beforehand calculated so that an image static control might be performed to a low frequency band is set to the IIR filters 5a and 5b. The multiplier beforehand calculated so that an image static control might be performed to a high-frequency band is set to the FIR filters 6a and 6b.

[0016] Drawing 2 is drawing showing the result of having carried out the image static control of the front L channel signal. If the listening person 8 hears the playback sound from the playback units 7a and 7b, it can be sensed that it is reproduced from the front L loudspeaker 9.

[0017] Next, the calculation approach of a multiplier is explained. Drawing 3 is equipment which measures the head sound transfer function used as the target of the

image normal position. A loudspeaker 9 is installed in the direction of 30 left from the transverse plane of a dummy head 12. The measurement signal generator 10 to a measurement signal is reproduced from the loudspeaker 9 which is a real source. The microphones 13a and 13b installed in the ear hole of a dummy head 12 detect this playback sound. The transfer function measuring instrument 11 measures the head sound transfer function Hl from a loudspeaker 9 to microphone 13a, and the head sound transfer function Hr from a loudspeaker 9 to microphone 13b using the measurement signal and microphone detecting signal from the measurement signal generator 10.

[0018] Drawing 4 is equipment which measures the transfer function of the playback unit attached in headphone. The dummy head 12 is correctly equipped with headphone, and the measurement signal from the measurement signal generator 10 is reproduced from the playback units 7a and 7b. The microphones 13a and 13b installed in the ear hole of a dummy head 12 detect this playback sound. The transfer function measuring instrument 11 measures the transfer function Cl of playback unit 7a, and the transfer function Cr of playback unit 7b using the measurement signal and microphone detecting signal from the measurement signal generator 10.

[0019] Since what is necessary is just to be able to reproduce Hl and Hr close to his ears of a dummy head 12 if the transfer function realized by the image static control is set to Xl and Xr, respectively, it becomes Hl=Xl−ClHr=Xr−Cr. Therefore, what is necessary is for an image static control just to realize the transfer function used as Xl=Hl/ClXr=Hr/Cr.

[0020] Drawing 5 is drawing showing the amplitude frequency characteristic of the head sound transfer functions Hl and Hr. Although it has the property with complicated Hl and Hr in the frequency band higher than about 1kHz, it has the property with monotonous Hl and Hr in the frequency band 1kHz or less. Drawing 6 is drawing showing the impulse response of the head sound transfer functions Hl and Hr. It turns out that time amount deltat0 was taken for the sound from a sound source to reach to a left ear, and time amount deltat0+deltat is taken to reach to a right ear. About a low frequency band, both the lugs level difference alpha and both lugs time difference deltat show that a head sound transfer function can be amended with a sufficient precision from the property of drawing 5 and drawing 6 .

[0021] Drawing 7 is drawing showing the amplitude frequency characteristic of the acoustic features Cl and Cr of headphone. The acoustic features Cl and Cr of headphone show the monotonous property in the wave number band 1kHz or less. From these results, the image static control of a high−frequency band should just use an FIR filter using an IIR filter with few image static controls to the number of taps of a low frequency band.

[0022] Drawing 8 is drawing showing the configuration of the IIR filters 5a and 5b. 25a−25g are [an adder, and 27a and 27b of a gain setter and 26a−26f] delay machines. The inputted signal branches to the signal inputted into delay machine 27a,

and the signal inputted into gain setter 25a, and the signal processed by delay machine 27a branches to the signal inputted into delay machine 27b, the signal processed by gain setter 25b, and the signal processed by gain setter 25e. After connecting this signal processing of a series of two or more times, processing it and adding the output signal of a gain setter with an adder, it adds to the output of the signal inputted and gain setter 25a. Delay processing of a unit sample is performed with the delay vessels 27a and 27b. Moreover, when connecting the above-mentioned signal processing n times and processing it, filter factors, i.e., the multiplier set as the gain setters 25a-25g, are b0, b1, b2, bn, c1, c2, and cn, respectively, and it can adjust the property of an output signal by changing the value of these multipliers.

[0023] The filter factor of the IIR filters 5a and 5b expresses the frequency characteristics of 1/Cl1/Cr which are the reverse properties of the acoustic features Cl and Cr of headphone, and in a frequency band higher than 1kHz, it computes a multiplier in a frequency band 1kHz or less so that flat frequency characteristics may be expressed. Furthermore, to this multiplier, the adjustment to both the lugs level difference alpha that is the property of the low frequency band of a head sound transfer function is added, and it gives b0, b1, b2, ..., bn, c1, c2, ..., cn by making it into a filter factor. Since both lugs time difference deltat is expressed in the FIR filter which performs the image static control of a high-frequency band, both the lugs time difference expressing the property of the low frequency band of a head sound transfer function is not expressed with an IIR filter.

[0024] Drawing 9 is drawing showing the configuration of the FIR filters 6a and 6b. 25a-25d are [an adder, and 27a and 27b of a gain setter, and 26a-26c] delay machines. The inputted signal branches and is inputted into the gain setters 25a-25d. When there is n+a gain setter, by the time the output signal which is 25d of gain setters is inputted into adder 26a, n delay processings will be performed. Delay processing of a unit sample is performed with the delay vessels 27a and 27b. Moreover, filter factors, i.e., the multiplier set as the gain setters 25a-25d, are a0, an-2, an-1, and an, respectively, and it can adjust the property of an output signal by changing the value of these multipliers.

[0025] The filter factor of the FIR filters 6a and 6b gives a multiplier in a low frequency band so that the amplitude frequency characteristic of transfer functions Xl and Xr may be expressed for flat frequency characteristics in a high-frequency band. To this multiplier, both lugs time difference deltat is amended, a multiplier is adjusted, and to the output of FIR filter 6b, the output of FIR filter 6a adjusts only level alpha so that it may become small, and it gives the amendment to both the lugs level difference alpha to a0, ..., an-2, an-1, and an as a filter factor.

[0026] Also in the case of other multichannel signals, the above is realizable with the same view, although the front L channel signal was made into the example and explained.

[0027] Furthermore, the image static control of a multichannel signal is also possible

by performing the same signal processing as coincidence to multichannel signals, such as DVD. Drawing 10 is image static-control equipment of the digital signal of six channels inputted from a DVD player. A delay machine and 15a-15h of the IIR filter with which 5a-5j perform a low-pass image static control, the FIR filter with which 6a-6j perform a high region image static control, the playback unit by which 7a and 7b were attached in headphone, the listening person whom 8 equipped with headphone, and 14 are adders.

[0028] The image static-control means of a pin center,large channel signal, a front R channel signal, a surround L channel signal, and a surround R channel signal is arranged to juxtaposition, and the adder adding the Ufa channel signal by which delay processing was carried out with five channel signals by which added the delay machine for delay of the Ufa channel signal, and the image static control was carried out is added. Since actuation of the image static control of a pin center,large channel signal, a front R channel signal, a surround L channel signal, and a surround R channel signal was already explained, the addition of each channel signal by which the image static control was carried out to delay processing of the Ufa channel signal is explained.

[0029] The inputted Ufa channel signal is outputted without carrying out an image static control. When adding with other channel signals by which the image static control was carried out in 15d of adders, and 15h of adders, in order to double the synchronization of a signal, only the time amount which signal processing for an image static control takes to other channel signals must be delayed to the Ufa channel signal. Therefore, the time amount which signal processing for the image static control of other channel signals takes is set as the delay machine 14. Each channel signal by which the image static control was carried out to the Ufa channel signal by which delay processing was carried out is added in Adders 15a-15h, and it outputs from the playback units 7a and 7b of headphone.

[0030] In addition, although the image static control of the inputted Ufa channel signal is not carried out, it is also possible to perform an image static control to the Ufa channel signal by adding the inputted Ufa channel signal, before the image static control of other channel signals is carried out and being processed by Addition 5a-5j, i.e., IIR filters.

[0031] Next, the case where the signal by which the image static control was carried out is reproduced using two loudspeakers is explained. Drawing 11 is image static-control equipment of the L front sound source at the time of making two loudspeakers into a playback means. A listening person, the loudspeaker reproduced through the amplifier which does not illustrate the signal with which 16a was carried out for the IIR filter with which 5a and 5b perform a low-pass image static control, the FIR filter with which 6a and 6b perform a high region image static control, and 8, and the image static control of a cross talk cancellation circuit, and 17a and 17b was carried out for 16b, and 18a and 18b are subtractors. It is the configuration of having

made Loudspeakers 17a and 17b into the playback means instead of headphone, and having added the cross talk cancellation circuits 16a and 16b and Subtractors 18a and 18b. Since the image static control using the IIR filters 5a and 5b and the FIR filters 6a and 6b was already explained, a setup of the transfer functions X1 and X2 of the cross talk cancellation circuits 16a and 16b is explained.

[0032] The cross talk transfer function Srl of a left ear is negated from right loudspeaker 17b by subtracting the output signal of cross talk cancellation circuit 16a from the output signal of FIR filter 6b, and the cross talk transfer function Slr of a right ear is negated from left loudspeaker 17a by subtracting the output signal of cross talk cancellation circuit 16b from the output signal of FIR filter 6a. If the cross talk transfer function Srl of a left ear and the cross talk transfer function Slr of a right ear are expressed using the head sound transfer functions Hl and Hr to the left ear of L fronts, and a right ear Sll(Hl−Hr−X2)+Srl(Hr−Hl−X1) =Hl Srr(Hr−Hl−X1)+Slr(Hl−Hr−X2) =Hr is materialized.

[0033] If X1 and X2 in which these simultaneous equations are materialized are calculated, playback of the front L loudspeaker by Loudspeakers 17a and 17b is realizable. That is, it is in the cross talk cancellation circuits 16a and 16b. X1= (Hl−Slr−Hr−Sll+Hr−Sll−Srr−Hr−Srl−Slr)/Hl (Sll−Srr−Srl−Slr)

X2= (Hr−Srl−Hl−Srr+Hl−Sll−Srr−Hl−Srl−Slr)/Hr (Sll−Srr−Srl−Slr)

What is necessary is just to give the becoming transfer function.

[0034] By the above, the low frequency band property of a head sound transfer function is approximated by both the lugs level difference and both lugs time difference, an IIR filter realizes the amendment, and since an FIR filter amends, control precision can be raised in the high−frequency band where a head sound transfer function shows a complicated property.

[0035] Moreover, since an IIR filter performs in a low frequency band and an FIR filter also performs property amendment of a sound reproduction means in a high−frequency band, the burdens of signal processing are reducible.

[0036] In addition, in order to express the difference of the inclination of the property in the low frequency band of the head sound transfer function expressed with delta Hl/delta f in the case of a left ear, and the inclination of both lugs, before processing with an IIR filter, the multiplier which adds another IIR filter and amends the inclination of the target property in a low frequency band may be given, and a still more accurate image static control may be performed.

[0037] In addition, the transfer function low frequency band property of the playback unit of headphone may be amended by analog filter processing.

[0038] In addition, in the case of the image static control of a pin center,large channel sound source, it is also possible to consider as the configuration which used together the IIR filter which uses together the IIR filter which has mostly two head sound transfer functions in the configuration of drawing 1 as an equal, or has two with right−and−left both lugs, and the FIR filter, respectively.

[0039] (Gestalt 2 of operation) Drawing 12 is image static-control equipment of the L front sound source of the gestalt 2 of operation. A gain setter, and 20a and 20b of the listening person whom in 5a and 5b an FIR filter, and 7a and 7b equipped with the headphone playback unit, and, as for 8, an IIR filter, and 6a and 6b equipped with headphone, and 19a and 19b are delay machines.
[0040] After signal processing of the inputted L front acoustic signal is carried out with the IIR filters 5a and 5b, the gain setters 19a and 19b, the delay machines 20a and 20b, and the FIR filters 6a and 6b, it is inputted into the headphone playback units 7a and 7b. The listening person 8 listens to the output signal of the playback units 7a and 7b. The multiplier beforehand calculated so that the image static control of a low frequency band might be performed is set to the IIR filters 5a and 5b, the gain setters 19a and 19b, and the delay machines 20a and 20b. The multiplier beforehand calculated so that the image static control of a high-frequency band might be performed is set to the FIR filters 6a and 6b. If the listening person 8 hears the playback sound from the playback units 7a and 7b, it can be sensed being the same as that of the gestalt 1 of operation that it is reproduced from the front L loudspeaker 9.
[0041] Next, the calculation approach of the multiplier of the IIR filters 5a and 5b, the gain setters 19a and 19b, the delay machines 20a and 20b, and the FIR filters 6a and 6b is explained. The IIR filters 5a and 5b set up the multiplier beforehand calculated in the reverse property 1 of the acoustic feature of headphone/the frequency characteristics of Cl1/Cr so that frequency characteristics flat in a high-frequency band might be expressed in a low frequency band as amendment of the transfer function low frequency band property of the headphone playback units 7a and 7b which are playback means among the image static controls about a low frequency band. The gain setters 19a and 19b and the delay machines 20a and 20b set up the multiplier beforehand calculated so that both the lugs level difference alpha and both lugs time difference deltat might be amended as a head sound transfer function low-pass property among the image static controls about a low frequency band. deltat0 is given to delay machine 20a as a multiplier, and deltat0+deltat is given to delay machine 20b as a multiplier. The FIR filters 6a and 6b set up the multiplier beforehand calculated so that an image static control might be performed about a high-frequency band. However, in order for the delay machines 20a-20b to express both lugs time difference, the FIR filters 6a and 6b adjust a multiplier so that the impulse response may not have delay.
[0042] Also in the case of other multichannel signals, the view is the same, although the front L channel signal was made into the example and the above explained it.
[0043] In addition, the image static control of a multichannel signal may be performed by performing the same signal processing as coincidence to a multichannel signal.
[0044] In addition, although headphone are used as a means to reproduce the signal by which the image static control was carried out, two loudspeakers may be used as a

playback means.
[0045] In addition, analog filter processing may realize amendment of the transfer function low-pass property of the playback units 7a and 7b of headphone.
[0046] In the case of the image static control of a pin center,large channel sound source, a head sound transfer function mostly with right-and-left both lugs in addition, as an equal Use together two IIR filters in the configuration of drawing 12 , or use together two IIR filters and gain setters, respectively. Or it is also possible to consider as the configuration which uses together two IIR filters and gain setters, and a delay machine, respectively, or used together two IIR filters and gain setters, the delay machine, and the FIR filter, respectively.
[0047] In addition, although amendment of the transfer function low-pass property of the playback units 7a and 7b of headphone is divided by IIR filter 5a for left units, and IIR filter 5b for right units and amendment processing is carried out, it is also possible to consider that right-and-left both units are almost equal, and to use together and process one IIR filter.
[0048] By the above, amendments of the low frequency band of a head sound transfer function are a gain setter and a delay machine, amendment of the low frequency band of a sound reproduction means reverse property is an IIR filter, and since an FIR filter performs amendment of a high-frequency band, control precision can be raised.
[0049] (Gestalt 3 of operation) Drawing 13 is image static-control equipment of the L front sound source in the gestalt 3 of operation. The listening person whom an FIR filter, and 7a and 7b equipped with the headphone playback unit, and, as for 8, 6a and 6b equipped with headphone, and 19a and 19b of a gain setter, and 20a and 20b are [a delay machine and 21] IIR filters. The IIR filters 5a and 5b are deleted to the configuration in the gestalt 2 of operation, the IIR filter 21 is added, and it considers as the configuration which changed the arrangement location of the gain setters 19a and 19b and the delay machines 20a and 20b.
[0050] The IIR filter 21 sets up the multiplier which amends the transfer function low-pass property of the headphone playback units 7a and 7b which are playback means among the image static controls about a low frequency band. The delay machines 20a and 20b give a multiplier so that both lugs time difference may be amended. As delay to a left ear, deltat0 is given as a multiplier. About the delay to a right ear, in order to express by delay machine 20a and delay machine 20b, deltat is given to delay machine 20b as a multiplier. A multiplier is given to the gain setters 19a and 19b so that both the lugs level difference may be amended.
[0051] Although the front L channel signal was made into the example and the above explained it, the view is the same even when it is other multichannel signals which are in attainment of the sound to a right ear compared with a left ear.
[0052] Drawing 14 is image static-control equipment of a R front sound source. The listening person whom an FIR filter, and 7a and 7b equipped with the headphone playback unit, and, as for 8, 6a and 6b equipped with headphone, and 19a and 19b of a

gain setter, and 20a and 20b are [a delay machine and 21] IIR filters. It is possible to use together the delay machine which expresses the delay to a right ear by this configuration. Since fundamental image normal position actuation is the same as the configuration of drawing 13 , it explains how to give the multiplier of the delay machines 20a and 20b.

[0053] Contrary to Hl of drawing 6 and the impulse response of Hr having shown the delay to both lugs, the delay to a left ear will give deltat0 as a multiplier to delay machine 20a, if the delay to deltat0+deltat and a right ear is expressed with deltat0. About the delay to a left ear, in order to express by delay machine 20a and delay machine 20b, deltat is given to delay machine 20b as a multiplier. The same is said of the image static control of other channels which are in attainment of the sound to a left ear compared with a right ear.

[0054] In addition, two loudspeakers may be used as a playback means instead of headphone as a means to reproduce the signal by which the image static control was carried out.

[0055] In addition, analog filter processing may realize amendment of the transfer function low-pass property of the playback unit of headphone.

[0056] The capacity of a delay machine, i.e., memory, can be reduced by being able to reduce the amount of signal-processing operations of an image static control, since one signal processing with an IIR filter is reduced, and communalizing a part of delay processing to both lugs.

[0057] (Gestalt 4 of operation) Drawing 15 is image static-control equipment of the L front sound source in the gestalt 4 of operation. For a gain setter, and 20a and 20b, a delay machine and 22 are [the listening person whom in 5a and 5b an FIR filter, and 7a and 7b equipped with the headphone playback unit, and, as for 8, an IIR filter, and 6a and 6b equipped with headphone, and 19a and 19b / a high-pass filter, and 24a and 24b of a low pass filter and 23] adders.

[0058] Signal processing of the inputted acoustic signal is carried out with a low pass filter 22 and a high-pass filter 23, and the signal of a low frequency band and the signal of a high-frequency band are extracted, respectively. The output of a low pass filter 22 is the signal of a low frequency band, and signal processing is carried out with the IIR filters 5a and 5b, the gain setters 19a and 19b, and the delay vessels 20a and 20b. The output of a high-pass filter 23 is the signal of a high-frequency band, and signal processing is carried out with the FIR filters 6a and 6b.

[0059] The output of the delay machines 20a and 20b and the output of the FIR filters 6a and 6b are added with Adders 24a and 24b, and are inputted into the headphone playback units 7a and 7b. The listening person 8 listens to the output signal of the playback units 7a and 7b.

[0060] The IIR filters 5a and 5b set up the multiplier beforehand calculated so that the reverse property 1 of the acoustic feature of headphone/the frequency characteristics of Cl1/Cr might be expressed in a low frequency band as amendment

of the transfer function low-pass property of the headphone playback units 7a and 7b which are playback means among the image static controls about a low frequency band. The gain setters 19a and 19b and the delay machines 20a and 20b set up the multiplier beforehand calculated so that both the lugs level difference alpha and both lugs time difference deltat might be amended as a head sound transfer function low-pass property among the image static controls about a low frequency band. The FIR filters 6a and 6b set up the multiplier beforehand calculated so that an image static control might be performed about a high-frequency band. So, if the listening person 8 hears the playback sound from the playback units 7a and 7b, it can be sensed that it is reproduced from the front L loudspeaker 9 as ** is also shown in drawing 2 .

[0061] Next, how to give a multiplier is explained. The filter factor expressing the amplitude frequency characteristic in the high-frequency band of the transfer functions Xl and Xr explained with the gestalt 1 of operation is given to the FIR filters 6a and 6b which perform the image static control of a high region. The filter factor expressing the amplitude frequency characteristic in the transfer function 1 explained with the gestalt 1 of operation/the low frequency band of Cl1/Cr is given to the IIR filters 5a and 5b. A multiplier is given to the gain setters 19a and 19b so that both the lugs level difference alpha may be expressed. However, it is necessary to adjust so that the level of the output signal of the FIR filters 6a and 6b may be in agreement on the boundary (it considers as a crossed frequency hereafter) of a control frequency band. Therefore, frequency-characteristics Hgd_l of the signal processed by frequency-characteristics Hfir_l, Hfir_r and the IIR filters 5a and 5b, the gain setters 19a and 19b, and the delay machines 20a and 20b of the signal processed by the FIR filters 6a and 6b using the metering device shown by drawing 16 or drawing 17 and Hgd_r are measured.

[0062] Drawing 16 is equipment which measures the amplitude frequency characteristic of the output signal of the FIR filters 6a and 6b in the configuration of drawing 15 . After signal processing of the measurement signal from the measurement signal generator 10 is carried out with a high-pass filter 23 and the FIR filters 6a and 6b, it is reproduced from the playback units 7a and 7b. The microphones 13a and 13b installed in the ear hole of a dummy head 12 detect this playback sound. The transfer function measuring instrument 11 measures amplitude-frequency-characteristic Hfir_l of the output signal of the FIR filters 6a and 6b, and Hfir_r using the measurement signal and microphone detecting signal from the measurement signal generator 10.

[0063] Drawing 17 is equipment which measures the amplitude frequency characteristic of the output signal of the delay machines 20a and 20b in the configuration of drawing 15 . After signal processing of the measurement signal from the measurement signal generator 10 is carried out with a low pass filter 22, the IIR filters 5a and 5b, the gain setters 19a and 19b, and the delay vessels 20a and 20b, it is reproduced from the playback units 7a and 7b. The microphones 13a and 13b installed in the ear hole of a dummy head 12 detect this playback sound. The transfer

function measuring instrument 11 measures amplitude-frequency-characteristic Hgd_l of the output signal of the delay machines 20a and 20b, and Hgd_r using the measurement signal and microphone detecting signal from the measurement signal generator 10.

[0064] Drawing 18 is drawing showing frequency-characteristics Hfir_l and Hgd_l. Frequency-characteristics Hfir_r is the same result as frequency-characteristics Hfir_l, and since frequency-characteristics Hgd_r is the same result as frequency-characteristics Hgd_r, it does not illustrate it. In this drawing, it is written that level becomes the same in a high region about transfer function Hl/Cl and Hfir_l which should be realized by the image static control. The level difference gl of Hfir_l and Hgd_l in a crossed frequency is given as a multiplier of gain setter 19a. The level difference of frequency-characteristics Hfir_r and Hgd_r is similarly given as a multiplier of gain setter 19b.

[0065] Moreover, a multiplier is given to the delay machines 20a and 20b so that both lugs time difference deltat may be expressed. By the way, there is difference of the time amount TH which signal processing of the FIR filters 6a and 6b takes, and the time amount TL which signal processing of the IIR filters 5a and 5b, the gain setters 19a and 19b, and the delay machines 20a and 20b takes. Moreover, in FIR filtering, a phase shift may arise in an input signal and an output signal depending on a filter factor. In consideration of above-mentioned processing-time difference TH-TL and the delay alpha for compensation of a phase shift, deltat0+ TH-TL+alpha is given to delay machine 20a as a multiplier, and deltat0+delta t+TH-TL+alpha is given to delay machine 20b as a multiplier.

[0066] Also in the case of other multichannel signals, the above is the same, although the front L channel signal was made into the example and explained.

[0067] In addition, the image static control of a multichannel signal is also possible by performing the same signal processing as coincidence to a multichannel signal.

[0068] In addition, two loudspeakers may be used as a playback means instead of headphone as a means to reproduce the signal by which the image static control was carried out.

[0069] In addition, it is also possible to realize amendment of the transfer function low-pass property of the playback units 7a and 7b of headphone by analog filter processing.

[0070] In addition, although amendment of the transfer function low-pass property of the playback units 7a and 7b of headphone is divided by IIR filter 5a for left units, and IIR filter 5b for right units and amendment processing is carried out, it is also possible to consider that right-and-left both units are almost equal, and to use together and process one IIR filter.

[0071] In addition, although the control precision of a low frequency band falls, when reducing the amount of signal-processing operations further, it may be made the configuration which deleted the IIR filters 5a and 5b.

[0072] In addition, in image control of a pin center,large channel signal, it may think that the head sound transfer function of a left ear and a right ear is almost equal, and one level-setting machine may be used together and processed.
[0073] In addition, in image control of a pin center,large channel signal, it may think that the head sound transfer function of a left ear and a right ear is almost equal, and one level-setting machine and one delay machine may be used together and processed.
[0074] In addition, in image control of a pin center,large channel signal, it may think that the head sound transfer function of a left ear and a right ear is almost equal, and one FIR filter may be used together and processed.
[0075] In addition, before processing with the IIR filters 5a and 5b in the case of a left ear, if the multiplier which amends the inclination of the target property in the low frequency band of the head sound transfer function which adds another IIR filter and is expressed with delta HI/delta f is given, a still more accurate image static control is realizable.
[0076] Low-pass amendments of a head sound transfer function are a gain setter and a delay machine, low-pass amendment of a sound reproduction means reverse property is an IIR filter, and since an FIR filter performs high region amendment, control precision can be raised.
[0077] (Gestalt 5 of operation) Drawing 19 is image static-control equipment of the R front sound source in the gestalt 5 of operation. For a delay machine and 21, an IIR filter and 22 are [the listening person whom an FIR filter and 7a and 7b equipped with the headphone playback unit, and, as for 8, 6a and 6b equipped with headphone, and 19a and 19b / a gain setter, and 20a and 20b / a high-pass filter, and 24a and 24b of a low pass filter and 23] adders. The IIR filters 5a and 5b are deleted to the image static-control equipment of the gestalt 4 of operation, the IIR filter 21 is added, and it considers as the configuration which changed the arrangement location of the gain setters 19a and 19b and the delay machines 20a and 20b.
[0078] Here, image static-control actuation of a low frequency band is explained. The IIR filter 21 sets up the multiplier which amends the transfer function low-pass property of the headphone playback units 7a and 7b which are playback means among the image static controls about a low frequency band. With the delay vessels 20a and 20b, a multiplier is given so that both lugs time difference may be amended. As delay to a left ear, deltat0+ TH-TL+alpha is given to delay machine 20a as a multiplier. About the delay to a right ear, in order to express by delay machine 20a and delay machine 20b, deltat is given to delay machine 20b as a multiplier. A multiplier is given to the gain setters 19a and 19b as the gestalt 4 of operation explained that both the lugs level difference was amended.
[0079] Although the front L channel signal was made into the example and the above explained it, the view is the same even when it is other multichannel signals which are in attainment of the sound to a right ear compared with a left ear.

[0080] Drawing 20 is image static-control equipment of a R front sound source. For a gain setter, and 20a and 20b, as for an IIR filter and 22, a delay machine and 21 are [the listening person whom an FIR filter, and 7a and 7b equipped with the headphone playback unit, and, as for 8, 6a and 6b equipped with headphone, and 19a and 19b / a low pass filter and 23] high-pass filters. It is possible to use together the delay machine which expresses the delay to a right ear by this configuration. Since fundamental image normal position actuation is the same as the configuration of drawing 19 , it explains how to give the multiplier of the delay machines 20a-20b.
[0081] Contrary to HI of drawing 6 and the impulse response of Hr having shown the delay to both lugs, the delay to a left ear gives as a multiplier deltat0+ TH-TL+alpha to which it seasoned delay machine 20a with TH, TL, and alpha which were explained with the gestalt 4 of operation if the delay to deltat0+deltat and a right ear was expressed with deltat0. About the delay to a left ear, in order to express by delay machine 20a and delay machine 20b, deltat is given to delay machine 20b as a multiplier. The same is said of the image static control of other channels which are in attainment of the sound to a left ear compared with a right ear.
[0082] In addition, two loudspeakers may be used as a playback means as a means to reproduce the signal by which the image static control was carried out.
[0083] In addition, analog filter processing may realize amendment of the transfer function low-pass property of the playback units 7a and 7b of headphone.
[0084] The capacity of a delay machine, i.e., memory, can be reduced by being able to reduce the amount of signal-processing operations of an image static control, since one signal processing with an IIR filter is reduced compared with the configuration of the gestalt 4 of operation, and communalizing a part of delay processing to both lugs.
[0085]
[Effect of the Invention] The image static-control equipment of this invention explained above In the high-frequency band where a head sound transfer function shows a complicated property FIR filtering amends the property of a playback means in the property of a head sound transfer function. In the low frequency band which can express the property of a head sound transfer function with a sufficient precision according to the level difference and time difference of a sound in both lugs Since a gain setup and delay processing of an input signal amend the property of a playback means in the property of a head sound transfer function, the number of taps of the FIR filter used for an image static control can be made small, and the amount of signal-processing operations can be reduced. Moreover, since the property in the low frequency band of a head sound transfer function can be approximated with sufficient sufficient accuracy by said amendment, a listening person can be provided with the good image normal position.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] Drawing showing the image static-control equipment in the gestalt 1 of operation of this invention

[Drawing 2] Drawing showing the result of having carried out the image static control of the front L channel signal in the gestalt 1 of operation of this invention

[Drawing 3] Drawing showing the equipment which measures the target property in the gestalt 1 of operation of this invention

[Drawing 4] Drawing showing the equipment which measures the transfer function of the headphone in the gestalt 1 of operation of this invention

[Drawing 5] Drawing showing the amplitude frequency characteristic of the head sound transfer function of a L front sound source

[Drawing 6] Drawing showing the impulse response of the head sound transfer function of a L front sound source

[Drawing 7] Drawing showing the amplitude frequency characteristic of the transfer function of the headphone in the gestalt 1 of operation of this invention

[Drawing 8] Drawing showing the IIR filter in the gestalt of operation of this invention

[Drawing 9] Drawing showing the FIR filter in the gestalt 1 of operation of this invention

[Drawing 10] Drawing showing the image static-control equipment of the multichannel signal in the gestalt 1 of operation of this invention

[Drawing 11] Drawing showing the image static-control equipment which made the loudspeaker the output means in the gestalt 1 of operation of this invention

[Drawing 12] Drawing showing the image static-control equipment in the gestalt 2 of operation of this invention

[Drawing 13] Drawing showing the image static-control equipment in the gestalt 3 of operation of this invention

[Drawing 14] Drawing showing the image static-control equipment of the input signal of the channel which is in attainment of the sound to a left ear compared with a right ear in the gestalt 3 of operation of this invention

[Drawing 15] Drawing showing the image static-control equipment in the gestalt 4 of operation of this invention

[Drawing 16] Drawing showing the equipment which measures the amplitude frequency characteristic of the FIR filter output signal in the gestalt 4 of operation of this invention

[Drawing 17] Drawing showing the equipment which measures the amplitude frequency characteristic of the delay machine output signal in the gestalt 4 of operation of this invention

[Drawing 18] Drawing showing the amplitude frequency characteristic of the FIR filter

output signal in the gestalt 4 of operation of this invention, and a delay machine output signal

[Drawing 19] Drawing showing the image static-control equipment in the gestalt 5 of operation of this invention

[Drawing 20] Drawing showing the image static-control equipment of the input signal of the channel which is in attainment of the sound to a left ear compared with a right ear in the gestalt 5 of operation of this invention

[Drawing 21] The block diagram showing conventional image static-control equipment

[Description of Notations]

1a, 1b Delay section
2a, 2b Amplifier
3a, 3b IIR filter
4a, 4b FIR filter
5 Filter Factor Selection Means
5a, 5b, 5c, 5d, 5e, 5f, 5g, 5h, 5i, 5j IIR filter
6a, 6b, 6c, 6d, 6e, 6f, 6g, 6h, 6i, 6j FIR filter
7a, 7b Headphone playback unit
8 Listening Person
9 Loudspeaker
10 Measurement Signal Generator
11 Transfer Function Measuring Instrument
12 Dummy Head
13a, 13b Microphone
14 Delay Machine
15a, 15b, 15c, 15d, 15e, 15f, 15h Adder
16a, 16b Cross talk cancellation circuit
17a, 17b Loudspeaker
18a, 18b Subtractor
19a, 19b Gain setter
20a, 20b Delay machine
21 IIR Filter
22 Low Pass Filter
23 High-pass Filter
24a, 24b Adder
25a, 25b, 25c, 25d, 25e, 25f, 25g Gain setter
26a, 26b, 26c, 26d, 26e, 26f Adder
27a, 27b Delay machine